



1           4.       A method of extracting power, comprising the steps of:  
2           coupling a transducer that converts mechanical power to electrical power to a  
3 disturbance,  
4           coupling an electrical circuit to the transducer,  
5           controlling switches of the electrical circuit such that the switches switch at a  
6 frequency greater than two times an excitation frequency of the disturbance,  
7           extracting power from the transducer using the electrical circuit,  
8           storing extracted power, and  
9           powering the electrical circuit with power extracted from the disturbance.

1           5.       A system for extracting power, comprising:  
2           a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,  
4           an electrical circuit connected across the transducer such that a peak voltage  
5 experienced by the transducer is greater than two times higher than any peak voltage of  
6 an open circuit transducer due to the disturbance alone, the electrical circuit including  
7           an inductor including first and second terminals, the first terminal  
8 being connected to a first terminal of the transducer,  
9           a first subcircuit connected to the second terminal of the inductor and a  
10 second terminal of the transducer, the first subcircuit including a switch, and  
11           a second subcircuit connected to the second terminal of the inductor  
12 and the second terminal of the transducer, the second subcircuit including a switch, and  
13           a storage element for storing extracted power.

1           6.       A system for extracting power, comprising:  
2           a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,  
4           an electrical circuit connected across the transducer such that a peak voltage  
5 experienced by the transducer is greater than two times higher than any peak voltage of  
6 an open circuit transducer due to the disturbance alone, the electrical circuit including

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7 a rectifier circuit including first and second input terminals and first  
8 and second output terminals, the first and second input terminal being connected across  
9 first and second terminals of the transducer,  
10 an inductor including first and second terminals, the first terminal  
11 being connected to the first output terminal of the rectifier circuit, and  
12 a subcircuit connected to the second terminal of the inductor and the  
13 second output terminal of the rectifier circuit, the subcircuit including a switch, and  
14 a storage element for storing extracted power.

1 7. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,  
4 an electrical circuit connected across the transducer such that a peak voltage  
5 experienced by the transducer is greater than two times higher than any peak voltage of  
6 an open circuit transducer due to the disturbance alone, and  
7 a storage element for storing extracted power, the storage element and the  
8 electrical circuit being connected such that the storage element supplies power to the  
9 electrical circuit.

1 8. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,  
4 an electrical circuit connected across the transducer such that a peak voltage  
5 experienced by the transducer is greater than two times higher than any peak voltage of  
6 an open circuit transducer due to the disturbance alone,  
7 a storage element for storing extracted power, and  
8 an independent power source for supplying power to the electrical circuit.

1 9. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance, and

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4 an electrical circuit connected across the transducer such that a peak of the  
5 integral of the current onto and off the transducer is greater than two times higher than  
6 any peak of an integral of a current of a short circuit transducer due to the disturbance  
7 alone, the electrical circuit including  
8 an inductor including first and second terminals, the first terminal  
9 being connected to a first terminal of the transducer,  
10 a first subcircuit connected to the second terminal of the inductor and a  
11 second terminal of the transducer, the first subcircuit including a switch, and  
12 a second subcircuit connected to the second terminal of the inductor  
13 and the second terminal of the transducer, the second subcircuit including a switch, and  
14 a storage element for storing extracted power.

1 10. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance, and  
4 an electrical circuit connected across the transducer such that a peak of the  
5 integral of the current onto and off the transducer is greater than two times higher than  
6 any peak of an integral of a current of a short circuit transducer due to the disturbance  
7 alone, the electrical circuit including  
8 a rectifier circuit including first and second input terminals and first  
9 and second output terminals, the first and second input terminals being connected across  
10 first and second terminals of the transducer,  
11 an inductor including first and second terminals, the first terminal  
12 being connected to the first output terminal of the rectifier circuit, and  
13 a subcircuit connected to the second terminal of the inductor and the  
14 second output terminal of the rectifier circuit, the subcircuit including a switch, and  
15 a storage element for storing extracted power.

1 11. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance, and

4 an electrical circuit connected across the transducer such that a peak of the  
5 integral of the current onto and off the transducer is greater than two times higher than  
6 any peak of an integral of a current of a short circuit transducer due to the disturbance  
7 alone, and

8 a storage element for storing extracted power, the storage element and the  
9 electrical circuit being connected such that the storage element supplies power to the  
10 electrical circuit.

1 12. A system for extracting power, comprising:

2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance, and

4 an electrical circuit connected across the transducer such that a peak of the  
5 integral of the current onto and off the transducer is greater than two times higher than  
6 any peak of an integral of a current of a short circuit transducer due to the disturbance  
7 alone,

8 a storage element for storing extracted power, and

9 an independent power source for supplying power to the electrical circuit.

1 13. A system for extracting power, comprising:

2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a mechanical disturbance,

4 an electrical circuit including switching electronics connected across the  
5 transducer, the electrical circuit including

6 an inductor including first and second terminals, the first terminal  
7 being connected to a first terminal of the transducer,

8 a first subcircuit connected to the second terminal of the inductor and a  
9 second terminal of the transducer, the first subcircuit including a switch, and

10 a second subcircuit connected to the second terminal of the inductor  
11 and the second terminal of the transducer, the second subcircuit including a switch,  
12 control logic which switch the switching electronics at a frequency greater  
13 than two times an excitation frequency of the disturbance, and

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14 a storage element for storing extracted power.

1 14. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a mechanical disturbance,  
4 an electrical circuit including switching electronics connected across the  
5 transducer, the electrical circuit including  
6 a rectifier circuit including first and second input terminals and first  
7 and second output terminals, the first and second input terminals being connected across  
8 first and second terminals of the transducer,  
9 an inductor including first and second terminals, the first terminal  
10 being connected to the first output terminal of the rectifier circuit, and  
11 a subcircuit connected to the second terminal of the inductor and the  
12 second output terminal of the rectifier circuit, the subcircuit including a switch,  
13 control logic which switch the switching electronics at a frequency greater  
14 than two times an excitation frequency of the disturbance, and  
15 a storage element for storing extracted power.

1 15. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a mechanical disturbance,  
4 an electrical circuit including switching electronics connected across the  
5 transducer,  
6 control logic which switch the switching electronics at a frequency greater  
7 than two times an excitation frequency of the disturbance, and  
8 a storage element for storing extracted power, the storage element and the  
9 electrical circuit being connected such that the storage element supplies power to the  
10 electrical circuit.

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1 16. A system for extracting power, comprising:



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7 a rectifier circuit including first and second input terminals and first  
8 and second output terminals, the first and second input terminals being connected across  
9 first and second terminals of the transducer,  
10 an inductor including first and second terminals, the first terminal  
11 being connected to the first output terminal of the rectifier circuit, and  
12 a subcircuit connected to the second terminal of the inductor and the  
13 second output terminal of the rectifier circuit, the subcircuit including a switch, and  
14 a storage element for storing extracted power.

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1 19. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,  
4 an electrical circuit connected across the transducer and capable of extracting  
5 power from the transducer and applying power to the transducer during different intervals  
6 in the course of the disturbance, and  
7 a storage element for storing extracted power, the storage element and the  
8 electrical circuit being connected such that the storage element supplies power to the  
9 electrical circuit.

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1 20. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,  
4 an electrical circuit connected across the transducer and capable of extracting  
5 power from the transducer and applying power to the transducer during different intervals  
6 in the course of the disturbance,  
7 a storage element for storing extracted power, and  
8 an independent power source for supplying power to the electrical circuit.

1 21. A system for extracting power, comprising:  
2 a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance,



4 a sensor for measuring a mechanical state, and  
5 an electrical circuit coupled to the transducer and controlled based on the  
6 measured mechanical state, the electrical circuit being configured to extract power from  
7 the transducer and store extracted power.

1 22. The system of claim 21 wherein the electrical circuit comprises a  
2 resonant circuit.

1 23. The system of claim 21 wherein the electrical circuit comprises  
2 switches controlled based on the measured mechanical state.

1 24. The system of claim 21 further comprising a plurality of transducers  
2 configured for coupling to the disturbance.

1 25. A method, comprising the steps of:  
2 coupling a transducer that converts mechanical power to electrical power to a  
3 disturbance, and  
4 coupling an electrical circuit to the disturbance, wherein coupling the  
5 electrical circuit includes controlling switches such that all electrical power supplied to  
6 the transducer is derived from power extracted from the mechanical disturbance.

1 26. The method of claim 25 wherein power for the entire circuit is derived  
2 from power extracted from the mechanical disturbance.

1 27. The method of claim 25 wherein a part of the circuit is powered by an  
2 external source.

1 28. The method of claim 25 wherein a part of the circuit is powered by a  
2 battery.

1           29.    The method of claim 25 further comprising the step of applying  
2 extracted power to an external load.

1           30.    The method of claim 25 wherein the step of coupling the electrical  
2 circuit includes coupling a resonant circuit to the transducer.

1           31.    The method of claim 25 wherein controlling switches includes  
2 controlling a duty cycle of the switches.

1           32.    The method of claim 25 wherein the step of controlling includes  
2 monitoring a system state.

1           33.    The method of claim 32 wherein controlling switches includes  
2 controlling a duty cycle of the switches based on the system state.

1           34.    The method of claim 25 wherein the step of coupling the electrical  
2 circuit acts to increase oscillations of the disturbance.

1           35.    The method of claim 25 wherein the step of coupling the electrical  
2 circuit acts to dampen oscillations of the disturbance.

1           36.    The method of claim 25 wherein the step of coupling the transducer  
2 includes coupling a plurality of transducers to the disturbance.

1           37.    A system, comprising:  
2           a transducer that converts mechanical power to electrical power, the  
3 transducer configured for coupling to a disturbance, and  
4           an electrical circuit connected across the transducer, the electrical circuit  
5 containing active switches such that all electrical power supplied to the transducer is  
6 derived from power extracted from the mechanical disturbance.

1           38.    The system of claim 37 configured such that power for all of the  
2 circuit is derived from power extracted from the mechanical disturbance.

1           39.    The system of claim 37 further comprising an external power source  
2 for supplying power to a part of the circuit.

1           40.    The system of claim 39 wherein the external power source comprises a  
2 battery.

1           41.    The system of claim 37 configured for damping oscillations of a  
2 disturbance.

1           42.    The system of claim 37 wherein the electrical circuit comprises:  
2           an inductor including first and second terminals, the first terminal being  
3 connected to a first terminal of the transducer,  
4           a first subcircuit connected to the second terminal of the inductor and a second  
5 terminal of the transducer, the first subcircuit including a switch, and  
6           a second subcircuit connected to the second terminal of the inductor and the  
7 second terminal of the transducer, the second subcircuit including a switch.

1           43.    The system of claim 37 wherein the electrical circuit comprises:  
2           a rectifier circuit including first and second input terminals and first and  
3 second output terminals, the first and second input terminals being connected across first  
4 and second terminals of the transducer,  
5           an inductor including first and second terminals, the first terminal being  
6 connected to the first output terminal of the rectifier circuit, and  
7           a subcircuit connected to the second terminal of the inductor and the second  
8 output terminal of the rectifier circuit, the subcircuit including a switch.

1           44.    The system of claim 37 wherein the electrical circuit includes  
2 amplifier electronics.

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1           45.    The system of claim 44 wherein the amplifier electronics comprise an  
2 H-bridge.

1           46.    The system of claim 44 wherein the amplifier electronics comprise a  
2 half bridge.

1           47.    The system of claim 44 wherein the electrical circuit further includes  
2 control electronics for controlling the amplifier electronics.

1           48.    The system of claim 47 wherein the control electronics control a duty  
2 cycle of the amplifier electronics.

1           49.    The system of claim 37 wherein the electrical circuit further includes a  
2 sensor for monitoring a system state.

1           50.    The system of claim 37 further comprising a storage element.

1           51.    The system of claim 50 wherein the storage element comprises a  
2 capacitor.

1           52.    The system of claim 50 wherein the storage element comprises a  
2 rechargeable battery.

1           53.    The system of claim 50 wherein the storage element comprises two  
2 components connected in series, a side of the transducer being connected to a node  
3 between the two components.